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ABSTRACT

This document is a final report on a two-year study involving nine community colleges, four disciplines and two special programs, 49 faculty, and 2,381 students in an exploration of the relationship between developmental courses and computer-based instruction. The report begins with an introduction, a description of students needing developmental courses, the purpose of the study, a description of the actual participants, an identification of instructional models and student characteristics, the findings for successful instructional models (i.e. for reading, mathematics, writing, ESL, and other developmental programs) and for student characteristics, conclusion and recommendations, and references. The Invest Learning system, an integrated learning system, was the key instructional strategy implemented by all the programs in the study. The evidence clearly shows that the Invest system, when used properly, can be an effective instructional tool for developmental programs. Fourteen exemplary models emerged that illustrate a variety of successful applications. Students generally enjoyed working with computers, and student characteristics commonly considered to be obstacles to success in computer-based instruction, such as the comfort level with computers and typing, appear to have little impact on student success. (JJL)

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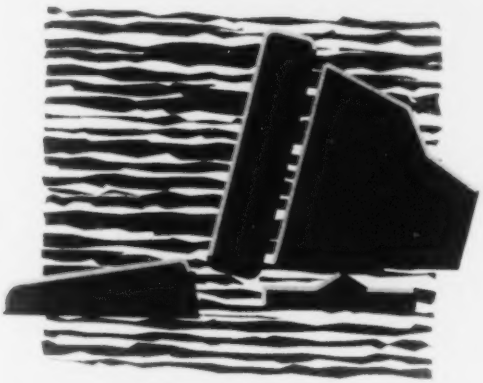

MEETING THE CHALLENGE

Final Report of the Computer-Based Developmental Education Project

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A Report to Invest Learning Corporation from the League for Innovation in the Community College

May 1996

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Final Report of the Computer-Based
Developmental Education Project

Larry Johnson
Stella Perez

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League for Innovation in the Community College

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Contents

Page

Abstract 1

Introduction 1

Developmental Students 2

Purpose of the Study 4

The Participants 4

Identification of Instructional Models and Student Characteristics 5

Findings 6

Section I: Instructional Models 6

Successful Instructional Models for Reading 7

Successful Instructional Models for Mathematics 8

Successful Instructional Models for Writing 9

Successful Instructional Models for English as a Second Language 9

Successful Instructional Models for Other Developmental Programs 10

Section II: Student Characteristics 11

Conclusions and Recommendations 13

References 15

MEETING THE CHALLENGE

Final Report of the Computer-Based Developmental Education Project

Abstract

Although community colleges are faced with a seemingly unending flood of underprepared students, state and local pressure is mounting to cut resources allocated to developmental education in states across the country. In this atmosphere, technology has been heralded as an answer to streamlining and adding efficiency to developmental efforts, but little has been done to document the value and outcomes of computer-based instruction for developmental students, and little is known about the factors influencing success in computer-based developmental coursework. This two-year study involved 9 community colleges, four disciplines and two special programs, 49 faculty, and 2,381 students in an exploration of the relationship between student outcomes in developmental courses and a variety of factors, including (a) student demographics, attitudes, and academic history, (b) unique aspects of the instructional software used in the developmental programs, (c) the instructional approaches used by developmental faculty, and (d) characteristics of the computer lab environment.

An integrated learning system—specifically the Invest Learning system—was used as a key instructional strategy by all of the programs investigated in the study. The evidence clearly indicates that the Invest system, properly used, can be an effective instructional tool for developmental programs. Fourteen exemplary models emerged that illustrate a variety of successful applications. Additionally, students were found to generally enjoy working with computers, and student characteristics commonly considered to be obstacles to success in computer-based instruction, such as the student's comfort level with computers and typing or keyboarding ability, appear to have little impact on student success.

Since the first community colleges were founded at the turn of the century, these institutions have been viewed as a "second chance" for adults to learn what they could not or did not learn in the public schools. In a way not seen since the land-grant movement in the 1800s, community colleges offered a new opportunity for thousands to participate in higher education. The open-access role of the community college was further expanded by the Truman Commission on Higher Education in 1947, which insisted that postsecondary education through the fourteenth grade be provided to all regardless of race, sex, religion, color, geographical location, or financial condition. As enrollments rose with the emerging baby boom, an increasing number of students entered with severe deficiencies in basic reading and math skills. By the late sixties, half of any community college freshman class was found to be deficient in essential academic skills (Roueche, 1968).

The situation has hardly changed since Roueche's landmark study more than 25 years ago. Cope (1978) found that less than half of all entering first-year community college students returned for a second year. Less than 20% eventually earned associate's degrees, and fewer than 10% went on to complete baccalaureate degrees. Wiener (1984) reported that 60% to 70% of all community college students were candidates for remedial courses. Describing the situation in California schools, he noted the effects of the low entry skills: Classes began with wall-to-wall students; by the end of the first census period, half were gone, unable to cope with the demands of college course work. By the

end of the second census period, the tenth week of instruction, only one-quarter to one-third remained.

Twelve years later, in community colleges across the country, Wiener's description still rings all too familiar. Bolstered by an increasing national focus on the competitiveness of America's work force, addressing the needs of the underprepared student remains one of the most pressing issues facing community colleges today. California community colleges, for example, spent $300 million in 1993-94 on remedial activities—11% of the total budget for community colleges statewide (Irving, 1996). The doggedness of the underprepared student issue is remarkable, and legislators are increasingly concerned about underprepared college students. As Roueche and Roueche (1993) observed, the public education system is not delivering a literate and well-prepared student product—one in four American youths drop out of school before entering the work force. (In Japan, by comparison, some 96% of students complete their secondary education before taking their first job.) Hardesty and Matthews (1991) reported that 37% of businesses participating in a national survey were forced to teach basic reading, writing, or math skills to their employees. Today, private corporations are educating and training employees at an annual cost estimated at almost $200 billion, nearly as much as the nation's colleges and universities are spending on their students. A significant proportion of those expenditures are being used for remedial courses in reading, writing, and math. In this context, attention is increasingly turning toward computer-based approaches as a possible cost-effective solution, especially given the lack of success with traditional approaches that plagues the developmental student population.

Developmental Students

Breneman and Nelson (1981, p. 22) found that "compared to students in other sectors of higher education, those in community colleges are more likely to be, on average, less wealthy, members of minority groups, older, part-time, working, and less well-prepared." Cross (1981) noted that students entered community college from the ghetto, the barrio, the reservation, and the suburbs; they were 20, 30, and even 70 years old; they were single parents preparing for careers, faltering students unsure of their skills, and hopeful students who were the first in their families to attend college. To complicate matters further, Roueche and Armes (1983) reported that many of these students entered with other problems such as debilitating anxiety, negative expectations, learned irresponsibility, and poor self-concepts. It was almost universally agreed among educators of the 1980s that the social, economic, and academic background of most community college students made it very difficult for them to persist in school (Astin, 1982).

Throughout the 1980s and into the present decade, the most difficult problems facing community college faculty and support staff have involved meeting the needs of the least academically prepared of these students, to whom a variety of terms have been attached, including disadvantaged, nontraditional, underprepared, remedial, developmental, high-risk, and underachieving (Moore, 1976; Roueche, 1977; Roueche & Roueche, 1993). These are the students most in need of developmental education. Roueche and Roueche (1993) noted that whatever these students are called, they carry the perception that they are less likely to succeed in their courses and to complete a program of study than their better-prepared counterparts. Kraetsch (1980) described them as lacking the solid educational base needed for success, a thought echoed by Campbell (1981), who observed that many

of them had fallen further and further behind during their public school years and were most likely ranked in the bottom third of their high school class. Weber described the "high risk" student quite succinctly: "They unconsciously regard themselves as educational failures on their way to fail again. That self-fulfilling prophecy is predictable from their behavior; they often come to class without pencil or paper, put off purchasing a text, sit near an exit, do not do initial assignments, become erratic in attendance. One day they simply vanish" (Weber, 1985, p. 1).

More than half of all community college students lack the skills for college-level work (McCabe, 1988); in urban institutions, the proportion of underprepared students can be as high as 75% to 95% (Richardson & Elliot, 1994). Nonetheless, despite the great numbers of students in need, developmental education programs in community colleges are under siege. California, Texas, and Florida lead the nation in reevaluating, reassessing, and possibly revoking remedial education efforts in higher education (Katsinas, 1994). State accountability and institutional effectiveness mandates of the 1990s are evidence of the growing discontent and perceived failure of public education efforts (Green & Gilbert, 1995).

The challenge to community colleges is to somehow continue to meet the needs of the large population of underprepared students with fewer and fewer college resources—and at the same time, answer the increased pressures to document and measure success. Parnell (1994) asserts that the at-risk population entering the open door of community colleges not only faces an uncertain future for themselves—the nation's future as a progressive society is no less at risk. The realities of changing demographics, increasing populations of the academically underprepared, and growing disparities among wage earners are serious issues for community colleges, and are made no less so by tremendous advances in information technology that widen the gap between the skilled and the unskilled. While a select cadre of students is entering higher education with the advantage of years of experience and familiarity with technology tools (Wilson, 1995), this advantage is not shared by those traditionally underserved in education. More than 60% of the American population has no exposure, experience, or access to computer-based technology (Hancock & Wingert, 1995).

Driven by the great difference in technological skills in the population and an increased focus on these approaches as possible cost-saving strategies, there is a growing debate on the effectiveness of computer-based instruction and how (and if) it contributes to academic success. Between 1988 and 1992, several meta-analyses of empirical research on the effectiveness of computer applications in schools were published. These studies focused on different time periods, educational levels, and computer applications, but in each of the studies, students who received assistance from computers generally learned more in classes, remembered longer, and spent less instructional time learning their lessons (Khalili, 1985; Kulik, 1991; Liao & Bright, 1991; Ryan 1991). A more recent meta-analysis of thirty-six independent studies showed that computer applications have a positive effect on students' academic achievement from elementary schools through college and university level curricula (Khalili and Shashanni, 1994). Unfortunately, almost no research has been conducted to determine the effectiveness of computer-based approaches for developmental students in community colleges; as a result, little is known about the benefits of these approaches for the developmental population.

Purpose of the Study

In the fall of 1993, in response to the need for research into the effectiveness of computer-based instruction for developmental students, the League for Innovation in the Community College issued an invitation for corporate sponsorship of a broad-based national study of the issue. Invest Learning Corporation accepted the invitation and offered its integrated learning system and substantial technical support at cost to colleges wishing to participate in the study. The agreement between Invest Learning and the colleges stipulated that the Invest system would be used to support developmental instruction in the context of the study, but colleges were free to use the system as they felt was appropriate for their student populations. Nine colleges accepted the offer and planning began for the project in January 1994. The fall term of 1994 was devoted to curriculum design, lab installations, and a pilot of the research instrumentation. Data collection began in the spring term of 1995 and continued through the fall.

The purpose of the study was twofold: 1) to identify and describe effective instructional models of computer-based instruction for each of the developmental disciplines; and 2) to identify student characteristics that contribute to or impede student success in computer-based developmental coursework.

The Participants

The nine colleges involved in the study represented seven states and included four urban colleges, two suburban colleges, and three rural or small colleges. Their student populations totaled 83,519 students. Developmental populations ranged from 4% to 83% of the enrollments in each institution. The colleges were: Central Arizona College, Coolidge, Arizona; Central Florida Community College, Ocala, Florida; The Community College of Denver, Denver, Colorado; Cuyahoga Community College, Cleveland, Ohio; El Centro College, Dallas, Texas; El Paso Community College, El Paso, Texas; Kingwood Community College, Kingwood, Texas; Miramar College, San Diego, California; and Santa Fe Community College, Santa Fe, New Mexico.

Table 1. Project Participants

College	Faculty	Class Sections	Students in the Study	Total Developmental Population	Total Student Population	Setting	Remediation Required
Central Arizona	6	7	130	287	7,148	Rural	N
Central Florida	12	15	404	1,065	6,105	Rural	N
Cuyahoga	3	6	88	3,424	21,608	Urban	N
Denver	3	6	319	5,523	6,661	Urban	Y
El Centro	5	7	439	1,502	4,349	Urban	Y
El Paso	5	6	95	10,537	20,162	Urban	Y
Kingwood	12	13	561	1,206	3,494	Suburban	Y
Miramar	2	3	274	982	8,310	Suburban	N
Santa Fe	1	1	71	676	5,682	Rural	N
TOTAL	49	64	2,381	25,202	83,519		

The 49 participating faculty provided access to 64 classes for the study, including 17 writing classes, 18 math classes, 15 reading classes, 3 English as a Second Language (ESL) classes, and 11 developmental classes of other types. All students in these classes were provided with a description of the purposes and goals of the study; 2,381 students signed an informed consent form and are included in the reported results.

Of the students who agreed to participate in the study, 665 were enrolled in writing, 877 in math, 564 in reading, 108 in ESL, and 167 in other developmental classes. The average age of these students was 25.8 years and 66% were female; 44% identified their ethnic group as Anglo, 21% as Hispanic, 25% as African American, 7% as Asian or Pacific Islander, and 3% as Other. Some 22% were repeating the course, 6% for the second time or more. Almost half of the students were continuing studies from the previous term, but 20%—a fifth—had been out of school for three years or more.

Grade point averages for reading and writing were comparable to the average for all developmental students across the colleges: 2.44 for students in reading courses (compared to 2.41) 2.32 for writing courses (compared to 2.36), and 2.36 for math courses (compared to 2.38). Drop rates were 16.7% for students in reading courses, 25.6% for writing courses, and 23.8% for math courses.

Identification of Instructional Models and Student Characteristics

The purpose of the study, as noted earlier, was twofold: 1) to identify and describe effective instructional models of computer-based instruction for each of the developmental disciplines; and 2) to identify student characteristics that contribute to or impede student success in computer-based developmental coursework. To accomplish the first purpose, a multiple analysis of variance was performed to determine if a significant difference could be found between the 64 sections involved in the study, with student grades and persistence as the dependent variables and course and institution as the independent variables. Age, gender, ethnicity, and four groups of variables from the student surveys (ability and comfort with computers; orientation toward using computers; academic history; and attitudes) were included in the model as covariates to control for the effects of these factors.

To aid in understanding the differences between college programs and to help identify the most effective instructional approaches, a summary sheet was prepared for each developmental discipline by college that included a range of information from each of the data sets, including course grade point average, average course persistence, and noncomputerized instructional strategies used in classes, as well as factors such as whether the computer activities were a formal part of the class, if the teacher was present when the computer activities took place, the presence of support staff or tutors, and the fit of the overall learning objectives with the software. Also included in the analysis were written reports from faculty and lab supervisors that addressed lab structure and philosophy issues, methods of instructional delivery, the correlation between instructional software and existing curricula, student attributes, and the relationship between time in the lab and other class activities.

To address the second purpose, frequencies and correlations were calculated on the student survey responses; additionally, a discriminant function analysis (DFA) was run on the entire set of 22 variables to determine factors influencing persistence and academic success. In the DFA, a random sample of cases was selected and two sets of analyses were run for each outcome variable.

The first required all variables to enter into the model at once, to ensure that the control variables were taken into account. Then the process was rerun, allowing a stepwise procedure, based on the minimization of Wilkes' lambda. The results of these analyses were then crossvalidated against the remaining cases to establish the consistency of the prediction models.

Findings

The findings related to the first purpose of the study (to identify and describe effective instructional models of computer-based instruction) are detailed in Section I below. The findings related to the second purpose of the study (to identify student characteristics that contribute to or impede success) can be found in Section II, beginning on page 11.

Section I: Instructional Models

The multivariate analysis of variance found significant differences ($p < .001$) between colleges on the outcomes of student grades and persistence, and within colleges by discipline ($p < .001$). (Summaries and descriptions of the most successful approaches by discipline are included in subsections beginning on page 7.) As noted previously, these results were interpreted using written reports and survey data from students, faculty, and lab supervisors.

A wide variety of instructional approaches were found, with considerable variation even between faculty on a single campus. In general, however, it appears that faculty who attended the computer lab with their students were more satisfied and more knowledgeable users. The sites with the strongest indicators of satisfaction among faculty and students had a clear service orientation within the lab and actively involved lab supervisors who contributed to the overall effort with training, classroom support, and problem resolution.

Most, but not all, faculty actively participated in computer lab activities. Some faculty held full class meetings in the lab, some held office hours in the lab, and others required students to work in the computer lab outside of normal class time. The amount of course time devoted to computer-based activities ranged from one to seven hours per week, and 10% to 75% of total class time was spent on lab-based work.

The most commonly used software package was the Invest Learning system, and instructors devised a number of unique applications using the Invest software and its related materials, especially the Invest workbooks. Faculty used the Invest software in a number of cooperative learning endeavors, including collaborative writing and editing assignments, critical-thinking projects, and personal development activities. "The ease of use" and "flexibility of the [Invest] system" were often mentioned as key factors in integrating the technology into instructional practices.

The reading and writing components of the Invest program were found to provide students valuable practice in language structure, comprehension, and mechanics. Spelling, vocabulary, capitalization, and punctuation skills were especially strengthened using Invest. Mathematics lessons addressed numeration, fractions, decimals, measurement, and geometry, as well as higher-level skills required for college algebra, trigonometry, and calculus.

Faculty also noted that the Invest system challenged students to justify their responses to particular questions. The instructional format forced students to employ a variety of strategies, such as predicting outcomes, making inferences, and distinguishing between relevant and irrelevant information. In addition, several faculty indicated that students' self-confidence and behavior improved as they spent more time using the lab facilities.

Comprehensive orientation activities were closely associated with successful strategies; most instructors used the Invest Learner Orientation guides to start students on the system. Most labs had a formal orientation process as well, and introduced the lab manager and/or tutors as part of the presentation, helping students become more familiar with the setting and more comfortable asking for assistance from lab staff. A clear association emerged between students' favorable perceptions of the appropriateness and capabilities of the Invest system and the presence of the instructor in the lab when assigned activities took place.

The role of the lab supervisor was complex at the sites which expressed the highest levels of faculty satisfaction, with the lab supervisor functioning as trainer, liaison, teacher-aide, and problem solver at various times. Furthermore, lab supervisors developed sophisticated customized curricula for the Invest system and helped to match course objectives to Invest lessons. These custom curricula were found very useful by faculty and were used in virtually all of the most successful approaches.

Successful Instructional Models for Reading

The reading programs at Central Florida, Cuyahoga, El Centro, and El Paso were found to be significantly superior to other approaches. Across these four programs, student persistence ranged from 78% to 95%. The proportion of the classes' total contact hours spent on computer activities was between one-third and two-thirds of the total class time, and students spent (on average) from 6.4 hours to 10.4 hours on the Invest system over the academic term. The instructors used the Invest system to teach about half of the learning objectives for the class, with the proportions ranging from 47% to 62%. In each of these programs, the following common elements of success were noted:

- Computer activities were a formal part of the class.
- A custom curriculum was used for Invest activities.
- Students received a comprehensive orientation to using the computers; to the Invest system and other software; to the lab resources, personnel, and policies; and to the class activities and grading. All used the Invest Orientation Guide in their orientations.
- All used several instructional software packages, with the largest proportion of assignments devoted to the Invest System.

Table 2. Distinctions among Successful Reading Programs

College	Teacher attends lab?	Tutors available in the lab?	Non-Invest Strategies	Students per station	Other factors
Central Florida	Y	N	Lecture, group work, collaborative projects	2	Practice on other software encouraged, but not mandatory
Cuyahoga	N	N	Group work, collaborative projects, other software	1	Independent study
El Centro	Y	N	Lecture, group work	1	Used for TASP remediation
El Paso	Y	Y	Lecture, group work, other software	1	Large lab, with group and individual areas

Successful Instructional Models for Mathematics

The mathematics programs at Central Arizona, Central Florida, and Cuyahoga were found to be significantly superior to other approaches. Across the three programs, student persistence ranged from 92% to 100%. The proportion of the classes' total contact hours spent on computer activities was between 37% and 55% of the total class time, and students spent (on average) from 6.4 hours to 10.4 hours on the Invest system over the academic term. The instructors used the Invest system to teach more than half of the learning objectives for the class, with the proportions ranging from 50% to 80%. In each of these programs, the following common elements of success were noted:

- Computer activities were a formal part of the class.
- A custom curriculum was used for Invest activities.
- Students received a comprehensive orientation to using the computers; to the Invest system and other software; to the lab resources, personnel, and policies; and to the class activities and grading. All used the Invest Orientation Guide in their orientations.
- Invest was the primary instructional software package available to students.

Table 3. Distinctions among Successful Mathematics Programs

College	Teacher attends lab?	Tutors available in the lab?	Non-Invest Strategies	Students per station	Other factors
Central Arizona	Y	Y	Lecture, group work, collaborative projects	1	Practice on other software encouraged, but not mandatory
Central Florida	Y	N	Lecture, other software	1	Invest workbooks are used for some homework
Cuyahoga	Y	N	Lecture, group work, other software	1	Practice on a variety of other software packages mandatory

Successful Instructional Models for Writing

The writing programs at Central Florida, Miramar, and Santa Fe were found to be significantly superior to other approaches. Across the three programs, student persistence ranged from 88% to 100%. The proportion of the classes' total contact hours spent on computer activities was between 43% and 50% of the total class time, and students spent (on average) from 6.1 hours to 10.4 hours on the Invest system over the academic term. The instructors used the Invest system to teach more than half of the learning objectives for the class, with the proportions ranging from 50% to 60%. In each of these programs, the following common elements of success were noted:

- Teachers were actively involved in lab activities.
- Computer activities were a formal part of the class.
- A custom curriculum was used for Invest activities.
- Students received a comprehensive orientation to using the computers; to the Invest system and other software; to the lab resources, personnel, and policies; and to the class activities and grading. All used the Invest Orientation Guide in their orientations.
- All used several instructional software packages, with the largest proportion of assignments devoted to the Invest System.

Table 4. Distinctions among Successful Writing Programs

College	Teacher attends lab?	Tutors available in the lab?	Non-Invest Strategies	Students per station	Other factors
Central Florida	Y	N	Lecture, group work, collaborative editing projects, other software	2	Used for CLAST remediation, keyboarding lessons encouraged
Miramar	Y	Y	Lecture, group work, collaborative editing projects, other software	1	Extensive use of tutors, individualized portfolios
Santa Fe	Y	Y	Lecture, group work, collaborative editing projects, other software	1	Used to satisfy required remediation

Successful Instructional Models for English as a Second Language

The ESL programs at Central Florida and El Paso were found to be significantly superior to other approaches. In both programs, student persistence was a remarkable 100%. The proportion of the classes' total contact hours spent on computer activities was between 30% and 43% of the total class time and students spent (on average) from 7.8 hours to 10.4 hours on the Invest system over the academic term. The instructors used the Invest system to teach many of the learning objectives

for the class (42% and 46%, respectively). In both programs, the following common elements of success were noted:

- Teachers were actively involved in lab activities.
- Computer activities were a formal part of the class.
- Bilingual tutors were available in the lab during class activities.
- A custom curriculum was used for Invest activities.
- Students received a comprehensive orientation to using the computers; to the Invest system and other software; to the lab resources, personnel, and policies; and to the class activities and grading. All used the Invest Orientation Guide in their orientations.
- Classes used immersion projects and audio and video resources extensively.
- Invest was the primary instructional software package available to students.

Table 5. Distinctions between Successful ESL Programs

College	Teacher attends lab?	Tutors available in the lab?	Non-Invest Strategies	Students per station	Other factors
Central Florida	Y	Y	Lecture, group work, collaborative projects	2	Practice on other software encouraged, but not mandatory
El Paso	Y	Y	Lecture, group work, collaborative projects, other software	1	Large lab, with group and individual areas

Successful Instructional Models for Other Developmental Programs

Two labs used the Invest system for nontraditional remediation very effectively. At Kingwood College, students met TASP non-course-based remediation requirements by self-remediating in the Invest Lab; 56% of students choosing this approach completed the semester successfully. The Community College of Denver used the Invest system in a required noncredit Basic Skills course as part of class and group work guided by a teacher; 100% of these students remained at the end of the semester. In both cases, other activities were available to the students, and students spent about half their time on computer activities. Students spent 13 hours (on average) using the Invest system over the academic term at the Community College of Denver. The instructors used the Invest system to teach more than half of the learning objectives for the class, with the proportions ranging from 54% at Kingwood to 62% in Denver. The following common elements of success were noted:

- Computer activities were a formal part of the class.
- Classes did not use lectures in any significant manner.
- A custom curriculum was used for Invest activities.

- Students received a comprehensive orientation to using the computers, to the Invest system and other software, to the lab resources, personnel, and policies, and to the class activities and grading. All used the Invest Orientation Guide in their orientations.
- Invest was the primary instructional software package available to students.

Table 6. Distinctions between Other Successful Developmental Programs

College	Teacher attends lab?	Tutors available in the lab?	Non-Invest Strategies	Students per station	Other factors
Denver	Y	N	Group work, computer practice	2	Portfolio-based individualized study
Kingwood	N	N	Computer practice, other software	1	Independent study

Section II: Student Characteristics

Students felt using the Invest system made learning the material easier; only 11% of students felt using the system made the courses harder. Most students (74%) felt their computer lessons were a good fit with other classwork, and 88% said they would enroll in a similar course again.

Over 70% had some typing skills before entering the course, and almost half of those felt their typing skills were very good. Nearly 60% of the students reported themselves comfortable with computers before the semester, but by midsemester 81% reported that they felt somewhat or very comfortable using computers. Seventy percent of students described themselves as having from "some" to "a lot" of computer experience before classes began.

Gender was significantly correlated with age and typing skills, indicating that on average, female students were older and better typists. Age was negatively correlated with all measures of computer experience and comfort. Older students were less experienced with computers, less comfortable with using computers, and took longer to become comfortable with the system. On average, older students were returning to school after a break in their studies.

Student comfort with *computers* was associated with computer experience, the degree to which they thought computer skills were not important to use Invest, and typing ability. Student comfort with the *class* was related to whether or not they thought the Invest lessons "were a good fit" with other course work; a good fit was correlated with greater comfort in the class. Additionally, student comfort in the class was related to how they perceived the computer's effect on the course workload, with less perceived work relating to a greater degree of comfort.

The time it took a student to get comfortable using the Invest system was positively related to the student's age—indicating that older students may need additional time and support at the start of the semester. An inverse relationship was found between students' perception that the Invest lessons are important (i.e., a "good fit") and the time it took them to become comfortable using the system. If faculty stress the value of these lessons in class, the time required for students to become comfortable may be reduced.

In general, being a member of a minority group or female was associated with longer amounts of time to become comfortable in the lab. The degree to which students felt they might enroll again in a similar course was inversely related to the time they required to become comfortable. Students inclined to enroll again in a similar course, by and large, became comfortable more quickly.

To aid in understanding these descriptive and correlational findings about students, a discriminant function analysis was conducted to determine key factors influencing persistence and academic success. (Discriminant function analysis is a classification algorithm that combines variables to build statistical models of the outcome variables.) Five student characteristics were found to form significantly predictive models of each of these outcomes. The factors are listed in Table 7 in decreasing order of their standardized discriminant function coefficients, which can be used to determine the relative importance of each of the factors.

Table 7. Discriminant Factors Ranked by Standardized Coefficients

Characteristics Predictive of Success	Characteristics Predictive of Persistence
1) Relatively lower levels of typing skills	1) Computer lessons considered a good fit
2) Somewhat experienced using computers	2) Being male
3) Workload considered similar to other courses	3) Feel computers make work easier
4) Being male	4) Comfortable with the system by mid-term
5) Relatively longer time to become comfortable using the system	5) Workload considered similar to other courses

The five factors that emerged in the academic success analysis correctly predicted success 65.43% of the time in the calibration sample. On crossvalidation, the correct classification rate degraded only slightly, and the model was found to explain 4.44% of the variance in academic success (F=19.0541). The five factors that comprised the persistence analysis correctly predicted success 72.6% of the time in the calibration sample. On crossvalidation, the correct classification rate degraded only slightly, and the model was found to explain 3.93% of the variance in academic success (F=16.752).

Two of the factors that emerged in the academic success analysis are surprising. A common perception among faculty is that typing or keyboarding skills are an important prerequisite for computer-based study. These results do not support that view, and indeed prior typing skills were found to be negatively related to success. Students who take a relatively longer time to become comfortable with the system appear to enjoy a higher rate of success than those who adjust to the system more quickly. This is also counter to conventional wisdom, and may indicate that these students are in fact delving deeper into the system than those reporting quicker adjustment periods.

The emergence of a gender-related factor in both analyses can be attributed to the fact that more males than females in the study reported having experience with computers before the course began. The remaining student characteristics associated with success and persistence include several factors that can be influenced by the teacher. A student's perception of whether or not computer lessons are a good fit with the learning objectives of the course is often based on comments or attitudes expressed by the instructor. Similarly, teacher comments and attitudes can influence how a student feels about the rigor of the work on the computer in comparison to other activities or other courses.

Conclusions and Recommendations

The nine community colleges involved in this study are similar in many respects to other colleges across the country and face many of the same challenges in dealing with large numbers of developmental students. The Invest Learning system was used as a key approach in four developmental disciplines and two special programs at these colleges and was used in significant ways in all of the programs found to be successful. The evidence clearly indicates that the Invest system, properly used, can be an effective instructional tool for developmental programs, and 14 exemplary models emerged from the analyses. These instructional models are based on generally accepted instructional practices and should be easily transferable to other developmental programs.

Students were found to generally enjoy working with computers, and student characteristics commonly considered to be obstacles to success in computer-based instruction, such as the student's comfort level with computers and typing or keyboarding ability, appear to have little impact on student success. The ancillary benefits that accrue to students under the instructional models described in this study are themselves significant. In addition to providing instruction in basic academic skills, the approaches described in this study also give developmental students valuable experience using technology—experience which they will carry forward into other courses, other programs, and ultimately the workplace. Computer-based developmental instruction targets those students who are least likely to have had experience with or access to technology. This study has demonstrated that they can nonetheless be successful using technology to learn. If such programs are expanded, they may serve to reduce the growing disparity between those who come to community colleges already well versed in technological skills and those increasingly disenfranchised students who have had little or no opportunity to develop those skills.

A large amount of effort at each of the participating colleges lies behind the successful completion of this research project. The contributions of the colleges in building the data collection mechanisms and infrastructure for this study are a significant resource that would greatly simplify continued research into this important area. The authors recommend that the study continue longitudinally to allow the exploration of evolutionary and other factors that may influence the effective use of computerized instruction for developmental students.

The application of computer-based instruction to developmental education is an area ripe for further investigation, especially given the scale of the need for developmental education and the societal and institutional factors driving the integration of technology into instructional programs. Much work remains to be done, not only in finding and describing effective models, but also in understanding the characteristics of learners that contribute to success. These findings are offered as a starting place for institutions wishing to move to computer-based developmental instruction and are but a small beginning of what is hoped will become a rich stream of continuing research into how computer-based approaches can be used effectively with developmental students.

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